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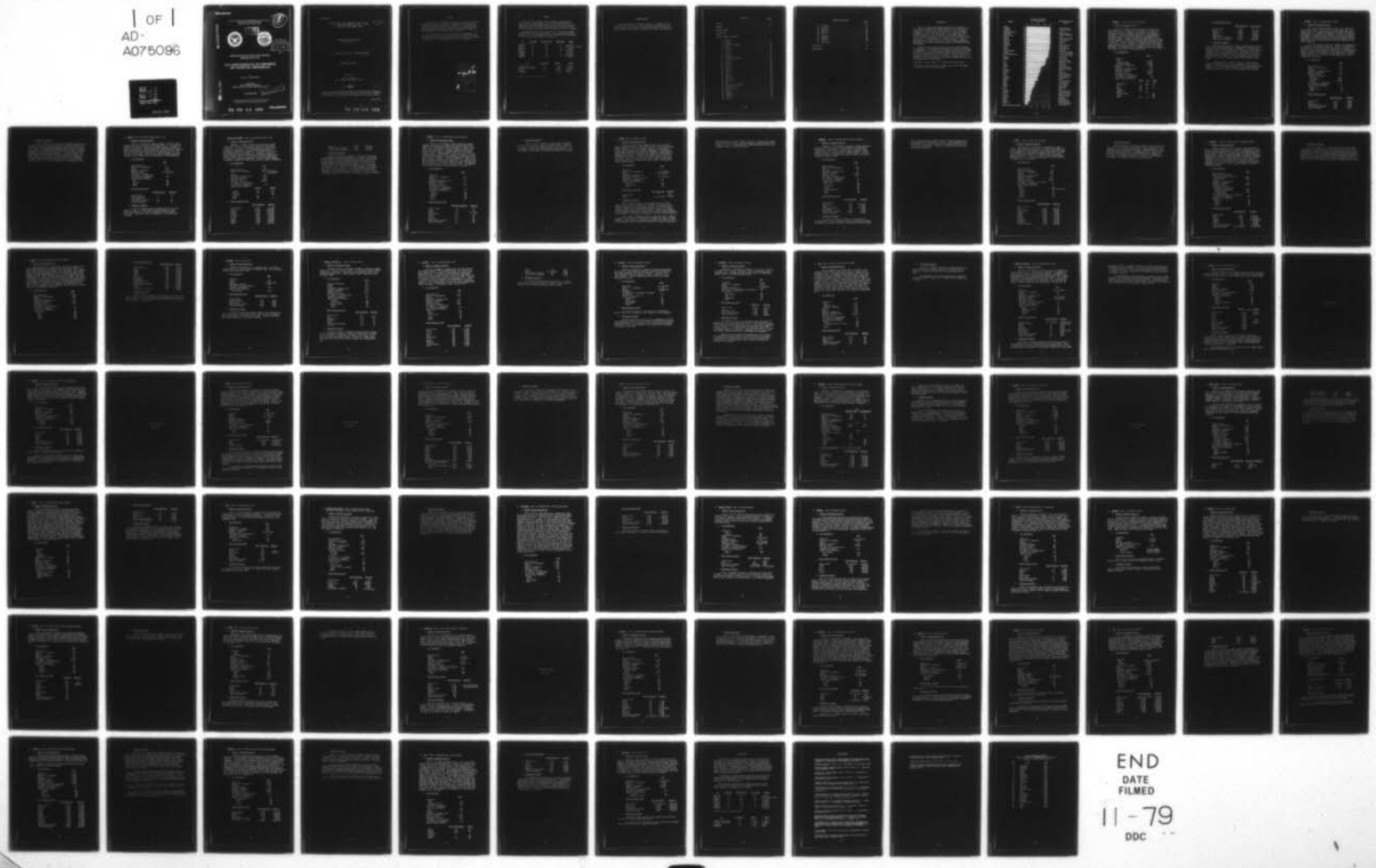

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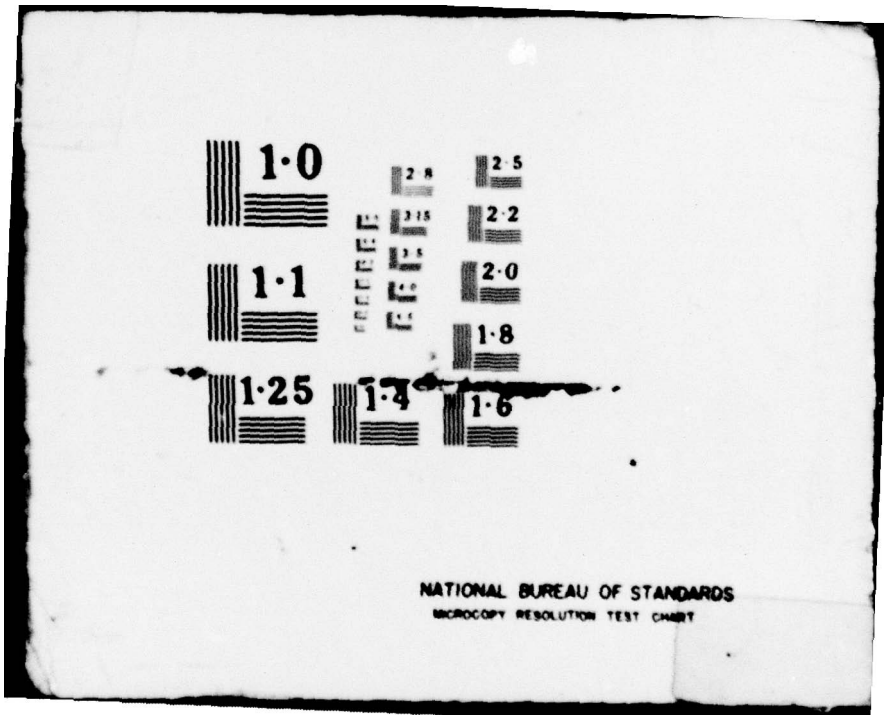
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HEADQUARTERS OF THE COMMANDER IN CHIEF PACIFIC
RESEARCH AND ANALYSIS OFFICE
CAMP H.M. SMITH, HAWAII 96861

RESEARCH AND ANALYSIS OFFICE
REPORT NO. 2-79

U.S. DEPENDENCE ON IMPORTS OF NONFUEL MINERALS

by
KARL H. EULENSTEIN

Approved by
ROY F. LINSENMEYER
CHIEF, RESEARCH AND ANALYSIS OFFICE

21 JUNE 1979

This working paper presents the findings of CINCPAC ANALYTICAL ADVISORS. It does not necessarily represent the views or policies of the Commander in Chief Pacific, nor should it be interpreted as an official finding.

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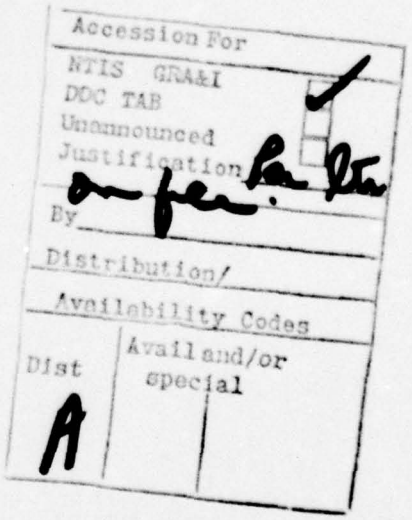
PREFACE

This report is a compilation of data on U.S. imports of nonfuel minerals and contains conclusions concerning alternate sources and sea lanes that would be important in wartime. It was prepared in response to the recurrent concern about certain sea lanes that have to be protected to guarantee availability of strategic minerals to the United States in a potential future conflict.

Most of the data are taken from recent U.S. Department of the Interior publications. The conclusions are attributable solely to the author and do not represent the official position of the Commander in Chief Pacific or any other agency of the U.S. Government.



SUMMARY

Of the 47 major nonfuel mineral commodities imported by the United States in 1978, imports of 12 must continue from sources beyond the Western Hemisphere during a crisis. The U.S. is not self-sufficient in these 12 minerals, and they are not obtainable from Western Hemisphere sources in sufficient quantity to meet U.S. demand.

Imported quantity of four of the twelve -- industrial diamonds, platinum metals, gallium and germanium -- is small enough to permit transport by air. The remainder, listed below, have to be transported by sea lanes from South Africa or Australia.

SEA	% IMPORTED	KILOTONS/YEAR	SHIPS/YEAR*	SOURCE
MANGANESE	98	1275	128	Australia
COBALT	97	9	1	Australia/S. Africa
CHROMIUM	92	1300	130	S. Africa
RUTILE	90	250	25	Australia
ASBESTOS	84	16	2	S. Africa
CADMIUM	66	3	1	Australia
ILMENITE	39	430	43	Australia
VANADIUM	27	4	1	S. Africa

AIR	% IMPORTED	AMOUNT	SOURCE
DIAMOND (INDUSTRIAL)	100	5 Tons	S. Africa
PLATINUM GROUP METALS	91	93 Tons	S. Africa
GALLIUM	26	3 Tons	Europe
GERMANIUM	12	3 Tons	Africa

*Based on 10,000 ton capacity ship.

ACKNOWLEDGMENTS

I wish to thank Dr. T. A. Henrie and Dr. J. D. Morgan, Jr., of the Bureau of Mines for their help in obtaining important data used in this report. Thanks, also, to Margaret Maruo and Irene Isara for their patience and diligence in preparing this report for publication.

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INTRODUCTION

The U.S. consumes more nonfuel minerals than it produces. In 1977, apparent consumption* of nonfuel minerals was valued at $171 billion. Net imports** were about $5 billion, or 3% of apparent consumption. In these terms, the overall U.S. reliance on imports of nonfuel minerals is not significant. On the other hand, for several key minerals, the U.S. relies totally (100%) on imports to satisfy apparent consumption. The extent of U.S. reliance on foreign sources for 47 important minerals is shown in Figure 1. Many of these minerals also are on the list of 93 basic stockpile materials maintained by the Federal Preparedness Agency of the General Services Administration.

Foreign sources for these minerals are distributed throughout both hemispheres, and imports are transported over the major sea lines of communication in all of the world's oceans. Because it is possible that the sea lanes along which bulk materials move to and from the U.S. may be interdicted by a potential enemy, a closer look at current imports and alternate sources is of interest. Minerals that are imported to satisfy more than 10% of apparent consumption are profiled in subsequent parts of this report.

*Apparent consumption equals U.S. production plus net imports.

**Net imports equal imports minus exports plus or minus Government stockpile and industry stock changes.

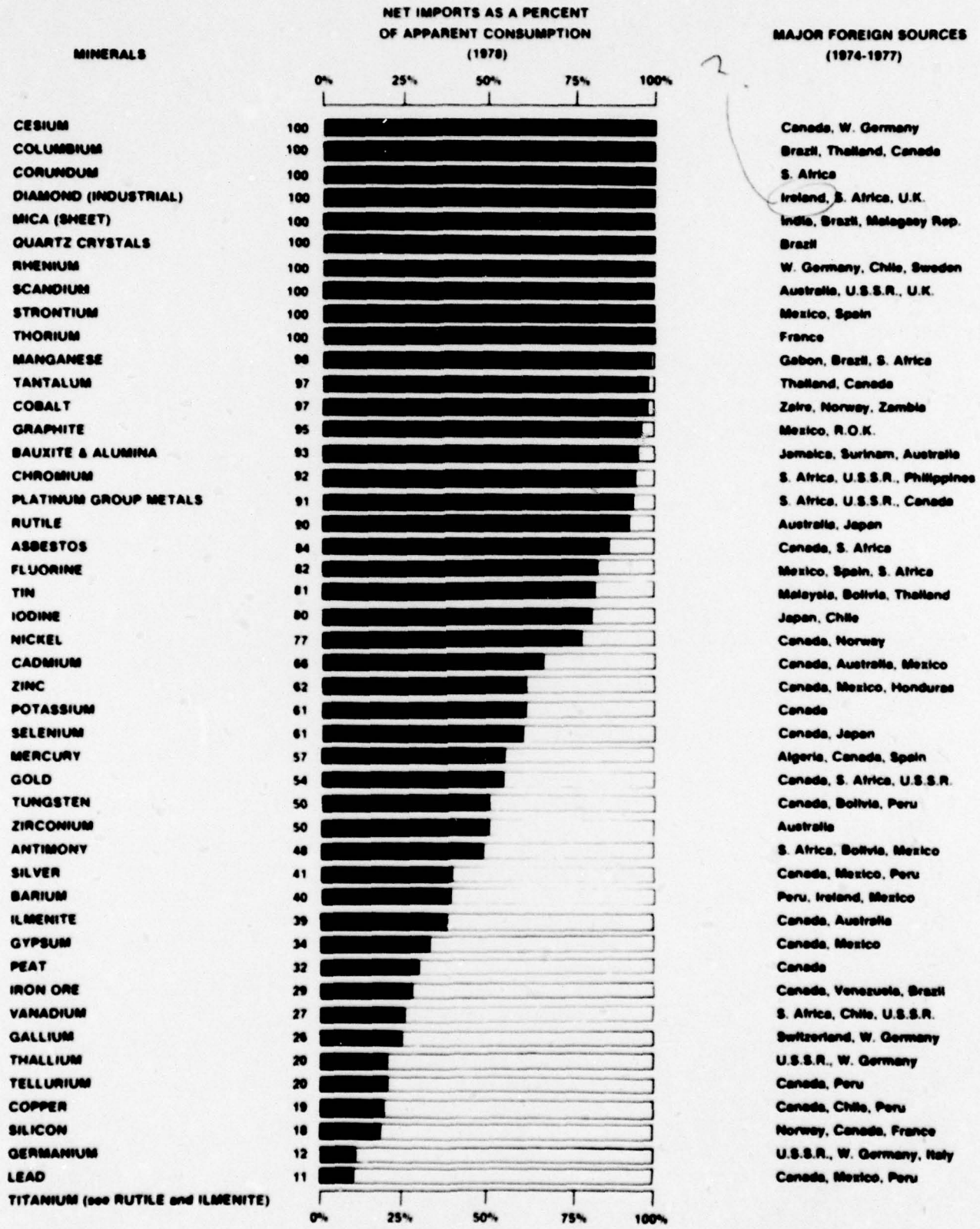
NET IMPORTS AS A PERCENT OF APPARENT CONSUMPTION (1978)
MINERALS
MAJOR FOREIGN SOURCES (1974-1977)
0%
25%
50%
75%
100%
CESIUM 100 Canada, W. Germany
COLUMBIUM 100 Brazil, Thailand, Canada
CORUNDUM 100 S. Africa
DIAMOND (INDUSTRIAL) 100 Ireland, S. Africa, U.K.
MICA (SHEET) 100 India, Brazil, Malagasy Rep.
QUARTZ CRYSTALS 100 Brazil
RHENIUM 100 W. Germany, Chile, Sweden
SCANDIUM 100 Australia, U.S.S.R., U.K.
STRONTIUM 100 Mexico, Spain
THORIUM 100 France
MANGANESE 98 Gabon, Brazil, S. Africa
TANTALUM 97 Thailand, Canada
COBALT 97 Zaire, Norway, Zambia
GRAPHITE 95 Mexico, R.O.K.
BAUXITE & ALUMINA 93 Jamaica, Surinam, Australia
CHROMIUM 92 S. Africa, U.S.S.R., Philippines
PLATINUM GROUP METALS 91 S. Africa, U.S.S.R., Canada
RUTILE 90 Australia, Japan
ASBESTOS 84 Canada, S. Africa
FLUORINE 82 Mexico, Spain, S. Africa
TIN 81 Malaysia, Bolivia, Thailand
IODINE 80 Japan, Chile
NICKEL 77 Canada, Norway
CADMIUM 66 Canada, Australia, Mexico
ZINC 62 Canada, Mexico, Honduras
POTASSIUM 61 Canada
SELENIUM 61 Canada, Japan
MERCURY 57 Algeria, Canada, Spain
GOLD 54 Canada, S. Africa, U.S.S.R.
TUNGSTEN 50 Canada, Bolivia, Peru
ZIRCONIUM 50 Australia
ANTIMONY 48 S. Africa, Bolivia, Mexico
SILVER 41 Canada, Mexico, Peru
BARIUM 40 Peru, Ireland, Mexico
ILMENITE 39 Canada, Australia
GYPSUM 34 Canada, Mexico
PEAT 32 Canada
IRON ORE 29 Canada, Venezuela, Brazil
VANADIUM 27 S. Africa, Chile, U.S.S.R.
GALLIUM 26 Switzerland, W. Germany
THALLIUM 20 U.S.S.R., W. Germany
TELLURIUM 20 Canada, Peru
COPPER 19 Canada, Chile, Peru
SILICON 18 Norway, Canada, France
GERMANIUM 12 U.S.S.R., W. Germany, Italy
LEAD 11 Canada, Mexico, Peru
TITANIUM (see RUTILE and ILMENITE)
0%
25%
50%
75%
100%

Figure 1

1. ANTIMONY (Data in short tons of metal)

a. Domestic Production and Use:

Nearly all domestic mine production of antimony was by two companies, one in Idaho and one in Montana. In Idaho the metal is recovered as a byproduct of complex silver-lead ores (tetrahedrite), while in Montana production is from antimony ore (stibnite). Additional antimony recovered as antimonial lead from the smelting of lead ore accounts for approximately 5% of the primary output. Primary antimony metal and oxide is recovered by seven companies utilizing both foreign (88%) and domestic (12%) raw materials. Primary antimony was consumed at about 300 plants in the Eastern States, accounting for approximately 90% of primary production. The principal uses of antimony, in 1978, were flame retardants, 42%; transportation, including batteries, 24%; chemicals, 13%; ceramics and glass, 11%; and other, 10%.

b. U.S. Statistics:

	1978
Production:	
Mine	1,000
Primary plants	13,300
Secondary plants	15,700
Imports for consumption	17,400
Exports	600
Government stockpile sales	0
Apparent consumption	32,000
Industry stocks	10,000
Government stockpile	40,729
Net imports as a percentage of apparent consumption	48%

Import sources 1974-1977:

	Metal	Ore	Oxide
South Africa		28%	48%
Bolivia	23%	22%	
PRC	19%		6%
Mexico	14%	25%	
Yugoslavia	16%		
Canada		24%	
United Kingdom			18%
France			15%
Other	28%	1%	13%

c. World Production 1978:

	Mine Production	Ore Reserves
United States	1,000	120,000
Bolivia	15,000	405,000
South Africa	10,000	350,000
Mexico	3,000	240,000
Yugoslavia	3,000	105,000
Other Market Economies	21,000	1,120,000
Other Central Economies	23,000	2,400,000

d. Alternative Sources:

Periods of short supply caused by increased military requirements have encouraged substitution. Compounds of titanium, zinc, chromium, tin, and zirconium may be substituted for antimony chemicals in paint, pigments, frits, and enamels. Combinations of calcium, strontium, tin, copper, selenium, sulfur, and cadmium can be used as substitutes in the hardening of lead. Antimony can be replaced as a flame retardant by a number of different compounds produced from elements such as boron, bromine, aluminum, and phosphorous, among others.

A large quantity of antimony alloys is continuously recycled, accounting for almost 50% of consumption. The automobile batteries in use represent approximately 190,000 tons of recoverable antimony. In any case, Mexico and Bolivia have enough production capacity and reserves to supply our import demand in an emergency.

2. ASBESTOS (Data in thousand metric tons)

a. Domestic Production and Use:

Most of the asbestos consumed in the U.S. is used by the construction industry. End uses are: asbestos-cement pipe, 24%; floor products, 23%; friction products, 14%; roofing, 9%; asbestos-cement sheets, 6%; coatings and compounds, 5%; paper, 4%; packing and gaskets, 4%; insulation, 3%; textiles, plastics and others, 8%. Six companies currently account for most of the asbestos produced domestically. The health hazards associated with asbestos and the scheduled closure of one mine portend a possible reduction in domestic production.

The three principal varieties of asbestos used commercially are chrysotile, crocidolite and amosite. The bulk of applications use chrysotile, most of which comes from Canada. Crocidolite is used in acid resisting packings and gaskets and asbestos-cement pipe. Amosite is used in marine turbines, jet engines and similar applications because of its resistance to high temperatures. These two forms of asbestos have significant military applications and are strategically important.

b. U.S. Statistics:

	1978
Mine production	91
Imports for consumption	535
Exports	43
Government stockpile sales	0
Apparent consumption	583
Industry stocks	83
Government stockpile:	
Chrysotile	9,943
Crocidolite	2,244
Amosite	38,480
Net imports as a percentage of apparent consumption	84%
Import sources 1974-1977:	
Canada	96%
South Africa	3%
Other	1%

c. World Production 1978:

	Mine Production	Reserves
United States	91	4,000
Canada	1,539	37,000
South Africa	380	5,000
Other Market Economies	690	13,000
Central Economies	2,900	28,000

d. Alternative Sources:

The U.S. demand for chrysotile can be satisfied indefinitely by imports from Canada. The small amounts of asbestos imported from South Africa are more important than they seem on the basis of quantity. The U.S. is completely dependent on South Africa for amosite and crocidolite, both strategically important in wartime. At present crocidolite is mined only in South Africa. The only source of commercial grades and quantities of amosite is also South Africa. Unless other sources of these two forms of asbestos are identified and exploited, the sea lanes from South Africa must be protected in wartime. However, the total quantity of amosite and crocidolite, about 16,000 metric tons, can be shipped by 2 or 3 merchant vessels.

3. BARIUM (Data in hundred thousand short tons)

a. Domestic Production and Use:

The U.S. is the world's largest consumer of barium. Barite production in 1978 climbed to a record high level of 1.7 million tons valued at $35 million. Production came from 8 States, with 80% of the total from Nevada. Other leading States were Arkansas and Missouri. About 2.8 million tons of ground barite was consumed in 1978. Over 90% of the barite produced was used as a weighting agent in oil and gas-well drilling muds. Other uses for barite included applications in paints, glass, rubber, and in the production of barium chemicals.

b. U.S. Statistics:

	1978
Mine production	1.7
Imports for consumption	1.1
Exports	0.04
Apparent consumption	2.8
Industry stocks	not available
Government stockpile	0
Net imports as a percentage of apparent consumption	40%
Import sources 1974-1977:	
Peru	30%
Ireland	21%
Mexico	13%
Other	36%

c. World Production 1978:

	Mine Production	Reserves
United States	1.7	25
Western Hemisphere (excluding U.S.)	0.7	11
Other Market Economies	2.8	46
Central Economies	0.9	21

d. Alternative Sources:

In 1952, the Defense Production Administration set a goal, achieved in 1955, to expand domestic barium production to meet defense requirements. No similar programs have been necessary since then. Furthermore, the U.S. potentially is self-sufficient in barium.

4. BAUXITE AND ALUMINA (Data in thousand dry metric tons)

a. Domestic Production and Use:

Aluminum is the most abundant structural metal element in the earth's crust. Its use exceeds that of any other metal except iron. Over 80% of the bauxite consumed in 1978 was used to produce aluminum metal. The remainder had applications in refractories, chemicals and abrasives. The great variety of uses for aluminum metal is well known. Until processes to extract alumina from the abundant non-bauxitic raw materials become economically feasible, the U.S. will continue to produce domestically less than 10% of apparent consumption. Currently, eight companies in Arkansas, Alabama and Georgia mine bauxite for domestic consumption.

b. U.S. Statistics:

	1978	
Mine production	1,700	
Imports for consumption	18,200	(80% bauxite, 20% alumina)
Exports	785	
Government stockpile sales	426	
Apparent consumption	5,200	
Industry stocks	6,500	
Government stockpile	14,563	
Net imports as a percentage of apparent consumption	93%	

Import sources 1974-1977:

	Bauxite	Alumina
Jamaica	43%	20%
Surinam	18%	11%
Australia		67%
Guinea	20%	
Other	19%	2%

c. World Production 1978:

	Mine Production	Reserves
United States	1,700	40,000
Australia	26,500	6,400,000
Guinea	12,000	8,200,000
Jamaica	11,400	2,000,000
Surinam	5,000	490,000
U.S.S.R.	4,700	200,000
Greece	3,000	750,000
Guyana	3,000	1,000,000
Hungary	3,000	300,000
India	1,500	1,600,000

Brazil	1,000	2,500,000
Other Market Economies	6,700	2,800,000
Other Central Economies	4,500	600,000

d. Alternative Sources:

Deposits containing aluminum in a form other than bauxite are widespread and virtually inexhaustible. However, constructing the facilities to extract alumina from these alternative materials on an industrial scale would require more than five years. U.S. imports comprise 80% bauxite and 20% alumina. Since all but 20% of the bauxite comes from the Western Hemisphere, no transoceanic sea lane protection is needed to obtain this commodity in wartime. Only the 2.6 million metric tons of alumina obtained from Australia would require sea lane protection if unobtainable in the Western Hemisphere. The combined production capacities of the U.S., Jamaica and Surinam probably are sufficient substitutes for Australian alumina.

5. CADMIUM (Data in thousand metric tons of metal)

a. Domestic Production and Use:

The U.S. is the world's largest consumer of cadmium. Cadmium is recovered as a byproduct of smelting domestic and imported zinc concentrates and from imported zinc smelter flue dusts. All of the domestic refinery production valued at $9 million was produced by six companies operating seven plants. During 1978 four companies produced about 80% of the domestic primary cadmium. Cadmium metal was used principally as a corrosion-resistant plating for metal components of machinery and outdoor electrical equipment. Cadmium compounds were used for pigments in paints, plastics, and ceramic materials. Domestic pigment and plating applications accounted for an estimated 15% and 45%, respectively, of the total cadmium consumed. The remaining 40% was used in alloys, plastic stabilizers, nickel-cadmium and silver-cadmium batteries, and photovoltaic solar cells.

b. U.S. Statistics:

	1978
Production	1.7
Imports for consumption	2.9
Exports	0.3
Government stockpile sales	0
Apparent consumption	5.1
Industry stocks	1.6
Government stockpile	2.9
Net imports as a percentage of apparent consumption	66%
Import sources 1974-1977:	
Canada	23%
Australia	16%
Benelux	13%
Mexico	12%
Other	36%

c. World Production 1978:

	Refinery Production	Reserves
United States	1.7	110
Japan	3.6	22
Belgium	1.7	not known
West Germany	1.3	4
Canada	1.2	140
Mexico	0.7	13
Australia	0.7	90
Other Market Economies	4.1	200
Central Economies	3.0	91

d. Alternative Sources:

If the U.S. had to depend on its own supply of cadmium, about half of the reserves would be consumed by 1985. Therefore, the U.S. will continue to depend on imports in the long run. In an emergency, Canada, Mexico and Australia could supply U.S. import needs. The sea lanes to Australia would have to be available.

6. CESIUM (Data in pounds of metal)

a. Domestic Production and Use:

Pollucite, the principal commercial ore of cesium, is not mined in the United States. Two California firms and two Pennsylvania firms accounted for all of the domestic output of cesium products. Cesium, usually in the form of chemical compounds, is used mainly in research and development, including the development of magnetohydrodynamic (MHD) electric power generators, thermionic energy converters, and biological research. Cesium is used commercially in electronic and medical applications. Cesium can be used to produce electricity from light. It has also been used in infrared lamps in sniperscopes and in the photocells of homing projectiles to track, intercept and destroy enemy aircraft.

b. U.S. Statistics:

	1978
Production	0
Imports for consumption	not available
Exports	not available
Government stockpile sales	0
Apparent consumption	not available
Net imports as a percentage of apparent consumption	100%
Import sources 1974-1977:	
Canada	75%
West Germany	23%
Other	2%

c. World Production 1978:

	Mine Production	Reserves
United States	0	small
Others	not available	109,000

d. Alternative Sources:

World pollucite reserves, which average about 20% cesium, appear to be sufficient for many years provided the projected rate of growth in demand is not significantly increased. The United States currently obtains all of its cesium ore and a large part of its manufactured cesium compounds from foreign sources. Future cesium supplies will be dependent upon foreign sources unless domestic pollucite deposits are discovered or technology is developed to use other low-grade materials.

Cesium forms independent minerals in pegmatites and is commonly obtained as a coproduct in the mining of tantalum, beryllium, or lithium minerals. World resources of cesium are not known, but reserves of pollucite probably could be increased substantially by intensive exploration.

Rubidium can replace cesium in many of its uses. Certain other elements can be substituted in light sensing equipment and potassium may be used instead of cesium in power generation. Western hemisphere sources are adequate to meet U.S. demand in wartime.

7. CHROMIUM (Data in thousand short tons gross weight)

a. Domestic Production and Use:

Chromium is one of the most important strategic materials. Its most prevalent uses are in three categories; metallurgical, chemical and in refractories. End uses are in stainless steel, metal plating, alloy steels, heating elements, pigments, leather tanning, catalysts and refractories. Although the U.S. is one of the world's largest consumers of chromium, no domestic mines have produced chromium since 1961.

b. U.S. Statistics:

	1978
Mine production	0
Imports for consumption	1,300
Exports	80
Government stockpile sales	0
Apparent consumption	590
Industry stocks	1,300
Government stockpile	3,877
Net imports as a percentage of apparent consumption	92%
Import sources 1974-1977:	
South Africa	36%
U.S.S.R.	14%
Philippines	12%
Turkey	10%
Southern Rhodesia	6%
Japan	3%
Other	19%

c. World Production 1978:

	Mine Production	Reserves
United States	0	0
South Africa	3,700	2,500,000
Turkey	700	5,500
Southern Rhodesia	660	1,100,000
Philippines	600	3,300
Other Market Economies	1,800	51,000
Central Economies	3,500	23,000

d. Alternative Sources:

Over 99% of the world's resources of chromium are in southern Africa. Even if economic incentives warranted restarting the domestic production of chromite, this production capacity would

not be sufficient to meet domestic demand. Imports from the U.S.S.R. are assumed to be not available in a crisis. Only South Africa has enough production capacity to supply U.S. demand increases in case the U.S.S.R. supply ceases. Thus, the sea lane from S. Africa must be protected in wartime.

8. COBALT (Data in short tons of metal)

a. Domestic Production and Use:

Cobalt usually is recovered as a byproduct of copper, nickel, iron, chromium, lead or zinc. Its most common application is as a component of high strength, heat and wear resistant alloys or in materials that have superior magnetic properties. End uses are in machine tools, carbides, jet engine parts, electronics, permanent magnets and paints. No cobalt has been produced domestically since 1971. Its strategic importance is due to its use in the manufacture of jet engines.

b. U.S. Statistics:

	1978	
Mine production	0	
Secondary production	300	
Imports for consumption	9,000	
Exports	800	
Government stockpile sales	0	
Apparent consumption	9,433	
Industry stocks	3,000	
Government stockpile	20,402	
Net import reliance as a percentage of apparent consumption	97%	
Import sources 1974-1977:		
Zaire	42%	
Benelux	23%	(from Zaire)
Zambia	7%	
Finland	6%	
Norway	12%	
Canada	7%	
Other	3%	

c. World Production 1978:

	Mine Production	Reserves
United States	0	0
Zaire	12,000	500,000
New Caledonia	4,600	300,000
Australia	3,800	54,000
Zambia	2,500	125,000
Canada	2,000	33,000
Morocco	2,000	14,000
Finland	1,500	20,000
Philippines	1,200	210,000
Botswana	200	29,000
Central Economies	4,000	350,000

d. Alternative Sources:

The identified U.S. resources of cobalt are more than 585,000 tons, located in the Midwest and Far West. These low grade resources currently are not economically exploitable. Manganese nodules on the ocean floor also contain cobalt. Although 90% of the imported cobalt comes from Europe and Africa, the combined production capacities of Australia, New Caledonia and Canada are sufficient to accommodate U.S. needs. In an emergency, the U.S. would have to protect the sea lanes either from Oceania or from Africa, but not both.

9. COLUMBIUM (Data in thousand pounds columbium content)

a. Domestic Production and Use

Columbium metal is used as an alloy in the manufacture of special steels and superalloys. At cryogenic temperatures, it can be used in superconductors of electricity. Some common applications are in bridges, towers and structures requiring high strength-to-weight ratios. Because of their resistance to corrosion, columbium based alloys are useful for ship structures, automobiles, railroad equipment and aircraft. Distribution of end uses in 1978 was: construction, 36%; transportation, 25%; oil and gas industry, 17%; machinery, 14%; other, 8%. Because no columbium has been produced domestically since 1959, the U.S. relies on imports for 100% of apparent consumption.

b. U.S. Statistics

	1978
Mine production	0
Imports for consumption:	
Concentrates, tin slags, etc.	2700
Ferrocolumbium	3900
Exports	30
Government stockpile sales	0
Apparent consumption	5700
Industry stocks	6384
Government stockpile:	
Columbium carbide powder	21
Columbium concentrates	1780
Ferrocolumbium	931
Columbium metal	45
Net import reliance as a percentage of apparent consumption	100%
Import sources 1974-1977:	
Brazil	73%
Thailand	8%
Canada	8%
Other	11%

c. World Production 1978

	Mine Production	Reserves
United States	0	0
Brazil	18,600	18,000,000
Canada	4,100	1,300,000
Malaysia	45	not available
Nigeria	700	700,000
Zaire	50	900,000
Other Market Economies	200	1,100,000
Central Economies	not available	not available

d. Alternative Sources:

The main sources of U.S. imports will continue to be Brazil and Canada. In an emergency, the U.S. could become self-sufficient in columbium by developing the Colorado pyrochlore and Idaho columbite-tantalite placer deposits. However, producing columbium domestically would double its cost. The estimated 300 million pounds of identified domestic deposits could satisfy U.S. cumulative demand for about 15 years. Thus, no transoceanic sea lanes need to be protected to insure that the U.S. will have a plentiful supply of columbium in time of war.

10. COPPER (Data in thousand short tons of copper)

a. Domestic Production and Use:

The United States is largely self sufficient in copper. Principal copper-producing states were Arizona, (65%); Utah, (14%); New Mexico, (9%); Montana, (5%); Michigan, (2%); and Nevada, (1%). Smelters were in the principal mining States with the exception of the El Paso, Texas, and Tacoma, Washington, facilities. Nearly 40% of the refinery capacity was near primary smelters with most of the remainder divided between locations in Texas and the Middle Atlantic States. Most copper was consumed as refined metal-69% by wire mills and 29% by brass mills. Use of copper (primary and old scrap) is estimated to be 58% electrical, 19% construction, 9% industrial machinery, 8% transportation, and 6% other. Significant quantities of byproducts and coproducts such as gold, silver, molybdenum, nickel, selenium, tellurium, arsenic, rhenium, lead, zinc, and sulfur were recovered.

b. U.S. Statistics:

	1978
Mine production	1,485
Imports for consumption	620
Exports	180
Government stockpile sales	0
Apparent consumption	2,480
Industry stocks	200
Government stockpile	22
Net imports as a percentage of apparent consumption	19%
Import sources 1974-1977:	
Canada	28%
Chile	21%
Peru	13%
Zambia	10%
Other	28%

c. World Production 1978:

	Mine Production	Reserves
United States	1,485	107,000
Chile	1,170	107,000
Canada	870	35,000
Zambia	700	37,000
Zaire	480	26,000
Peru	370	35,000
Philippines	290	20,000
Australia	210	9,000
Papua New Guinea	210	16,000
South Africa	210	6,000
Other Market Economies	757	85,000
U.S.S.R.	940	40,000
Poland	280	14,000
Other Central Economies	440	12,000

d. Alternative Sources:

Suitable copper substitutes are aluminum for electrical purposes, steel for shell casings and plastics for plumbing. In any case, the availability of copper in the western hemisphere is sufficient to meet U.S. needs in an emergency.

11. CORUNDUM (Data in short tons)

a. Domestic Production and Use:

Corundum is not produced in the United States. Its end uses are grinding and polishing of optical components (45%), fabricated metal products (40%), and others (15%).

b. U.S. Statistics:

	1978
Production	0
Imports	500
Exports	not available
Apparent consumption	500
Net imports as a percentage of apparent consumption	100%
Import sources 1974-1977:	
South Africa	100%

c. World Production 1978:

	Mine Production	Reserves
United States	0	0
Southern Rhodesia	3,000	large
South Africa	175	large
Other Market Economies	1,000	large
Central Economies	8,800	large

d. Alternative Sources:

Substitute abrasives are garnet, diamond, fused aluminum oxide and silicon carbide. Corundum was removed from the list of strategic and critical materials for stockpiling in 1969. Artificial abrasives can be substituted for all end uses of corundum.

12. DIAMOND (INDUSTRIAL) (Data in million carats)

a. Domestic Production and Use:

The United States is the largest consumer of industrial diamond and has no resources of natural diamond. All industrial diamond produced domestically is synthetic. Major end uses are machinery (32%), transportation equipment (20%), ceramic products (19%), construction (11%) and others (18%).

b. U.S. Statistics:

	1978
Production (natural)	0.0
Imports	21.6
Exports	22.3
Government stockpile sales	2.6
Apparent consumption	33.5
Industry stocks	0.0
Government stockpile	46.0
Net imports as a percentage of apparent consumption	100%
Import sources 1974-1977:	
Ireland	36%
South Africa	28%
United Kingdom	10%
Benelux	7%
Other	19%

c. World Production 1978:

	Mine Production	Reserves
United States	0.0	0
Zaire	11.0	500
South Africa	4.5	50
Botswana	2.5	50
Ghana	2.0	25
Other Market Economies	1.5	30
U.S.S.R.	8.2	25

d. Alternative Sources:

Successful synthesis of diamond by General Electric Company in 1954, followed by commercial production of diamond grit, has made the U.S. potentially independent of foreign sources except for the grit sizes larger than about 25 mesh. However, U.S. annual imports are less than 5 tons and can be flown in rather than transported by sea.

13. FLUORINE (Data in thousand short tons)

a. Domestic Production and Use:

The major consumers of fluorspar are: the steel industry, 50%: chemical industry, 20%; aluminum industry, 16%; others, 14%. About 20,000 tons of acid-spar are used annually to make uranium hexafluoride that is processed in gaseous diffusion enrichment plants of the nuclear power industry. There is no known substitute for fluorine in the process for enriching uranium (U235). Adoption of alternate fluxes in steelmaking, the improvements in fluorine recovery in the aluminum industry, and restrictions on fluorocarbon manufacture due to environmental concerns have reduced domestic production and demand. Three domestic mines closed in 1978.

b. U.S. Statistics:

	1978
Mine production	230
Imports for consumption	1,030
Exports	8
Government stockpile sales	0
Apparent consumption	1,250
Industry stocks	190
Government stockpile	1,308
Net imports as a percentage of apparent consumption	82%
Import sources 1974-1977:	
Mexico	67%
Spain	11%
South Africa	7%
Italy	4%
Canada	4%
Other	7%

c. World Production 1978:

	Mine Production	Reserves
United States	130	16,000
Mexico	1,000	39,000
U.S.S.R.	550	15,000
Spain	450	11,000
France	400	9,000
South Africa	400	78,000
P.R.C.	400	6,000
Mongolia	400	5,000
Thailand	250	11,000
United Kingdom	250	22,000
Italy	200	7,000

Kenya	150	15,000
Canada	not available	6,000
Other Market Economies	200	50,000
Other Central Economies	300	5,000

d. Alternative Sources:

The combined production capacities of the U.S., Canada and Mexico are sufficient to meet U.S. demand in case of war. No sources beyond the Western Hemisphere would be needed.

14. GALLIUM (Data in kilograms of metal)

a. Domestic Production and Use:

Gallium is recovered as a byproduct of processing aluminum and zinc ores. Known domestic resources of gallium are substantial, but current demand exceeds domestic production. End uses are in light emitting diodes for calculators, radios, television, clocks and instruments. Potential applications are in lasers, microwave and energy conversion.

b. U.S. Statistics:

	1978
Production	not available
Imports for consumption	2,400
Exports	not available
Consumption	8,500
Net imports as a percentage of apparent consumption	26%
Import sources 1974-1977:	
Switzerland	73%
Canada	4%
West Germany	15%
Netherlands	3%
Others	5%

c. World Production 1978:

The output of the world's few producers is confidential. World resources are estimated to be more than one billion kilograms.

d. Alternative Sources:

Alternative materials, such as silicon, germanium and indium, are available for almost all of the commercial applications of gallium. Since annual imports can be brought in by air and suitable substitute materials exist, sea lane protection is not required for the purpose of gallium in time of war.

15. GERMANIUM (Data in kilograms of metal)

a. Domestic Production and Use:

Germanium is recovered as a byproduct of zinc ores. End uses are primarily in electronic components (60%), instrumentation (36%) and others (4%). Germanium has special applications in chemotherapy, polymer chemistry and light emitting diodes.

b. U.S. Statistics:

	1978
Production	16,000
Imports for consumption	2,750
Exports	not available
Apparent consumption	22,000
Net imports as a percentage of consumption	12%
Import sources 1974-1977:	
U.S.S.R.	34%
West Germany	29%
Italy	15%
Netherlands	6%
Others	16%

c. World Production 1978:

	Production	Reserves
United States	16,000	390,000
Zaire	23,000	large
South-West Africa	7,000	large
Other Market Economies	34,000	large
Central Economies	9,000	moderate

d. Alternative Sources:

Less expensive silicon has increasingly been substituted for germanium in certain electronic applications. Certain tellurium, selenium, indium, and gallium bimetals may also be used; however, germanium is more reliable in some high-frequency and high-power requirements, and more economical as a substrate for some LED applications. In infrared guidance systems zinc selenide or germanium glass can substitute for intrinsic germanium metal but at the expense of performance.

Imports are small enough to be transported by air instead of sea, thereby precluding the need to protect sea lanes for this metal. If germanium were recovered from ash and flue dusts resulting from burning coal for power generation, the U.S. would be totally self sufficient in this metal.

16. GOLD (Data in million troy ounces of metal)

a. Domestic Production and Use:

Gold has emerged as an element that is essential to the aerospace and electronics industry in addition to being a world standard of value. The domestic mining industry consists of about 175 mines; nearly all in Western States; about half of these produce gold as a principal product. In 1978, 25 mines yielded 95% of the gold produced, and 3 of these accounted for 65%. About 1/3 of domestic gold is a byproduct of base metal mining, chiefly copper mining. The value of 1978 mine production was about $187 million. Commercial grade refined gold came from 36 producers; the number of fabricators is about 3,500. Nearly all jewelry manufacturing is centered in the New York City and Providence, R.I., areas. Estimated uses in 1978: jewelry and arts, 56%; industrial (mainly electronic), 27%; dental, 16%; small bars, etc., mainly for investment, 1%.

b. U.S. Statistics:

	1978
Production:	
Mine	0.97
Refinery, new	1.00
Refinery, secondary	3.10
Imports	4.68
Exports	5.66
Apparent consumption	5.40
Industry & future stocks	4.40
Treasury stocks	274.97
Net imports as a percentage of apparent consumption	54%
Import sources 1974-1977:	
Canada	44%
Switzerland (from S. Africa)	16%
U.S.S.R.	17%
Other	23%

c. World Production 1978:

	Mine Production	Reserves
United States	0.97	110
South Africa	22.9	580
Canada	1.7	45
Other Market Economies	5.8	200
Central Economies	8.2	260

d. Alternative Sources

Base metals clad with gold alloys are being used increasingly in electrical/electronic products to economize on gold. Generally, palladium, platinum, and silver may substitute for gold.

In an emergency, U.S. Treasury and industry stocks are more than adequate to supply the U.S. demand that is normally met by imports.

17. GRAPHITE (NATURAL) (Data in thousand short tons)

a. Domestic Production and Use:

The entire 1978 domestic production of natural graphite was from one mine in Texas. No byproducts, coproducts or secondary production were associated with the mining operation. Consumption of natural graphite was by several hundred manufacturing firms, located primarily in the northeastern and Great Lakes regions. In 1978, the main uses of natural graphite were estimated to be: Raising carbon content in steel production, 32%; refractories, 21%; dressings and molds in foundry operations, 12%; and crucibles, retorts, etc., 8%.

b. U.S. Statistics:

	1978
Production	not available
Imports for consumption	85
Exports	15
Government stockpile sales	0
Apparent consumption	not available
Industry stocks	not available
Government stockpile	26
Net imports as a percentage of apparent consumption	95%
Import sources 1974-1977:	
Mexico	72%
Republic of Korea	8%
Madagascar	6%
U.S.S.R.	3%
Others	11%

c. World Production 1978:

	Mine Production	Reserves
United States	not available	insignificant
Republic of Korea	75	insignificant
Mexico	65	large
Austria	40	small
Madagascar	20	large
West Germany	15	insignificant
Sri Lanka	10	small
Other Market Economies	60	small
Central Economies	265	small

d. Alternative Sources:

Substitute and alternate materials are more costly and/or do not perform as well as natural graphite for most applications. Manufactured graphite powder, scrap from replaced machined shapes, and calcined petroleum coke compete in iron and steel production. Finely ground

coke with olivine is a potential competitor in foundry facing operations. Molybdenum disulfide competes as a dry lubricant but is more sensitive to oxidative conditions. Teflon and similar materials do not substitute for graphite, but their increasing use as bearings has reduced the need for graphite lubricants.

In an emergency, several low-grade U.S. deposits could be worked but would require at least one year for development. The domestic output combined with imported Mexican amorphous graphite, or manufactured graphite and substitute materials, could achieve a measure of self-sufficiency for the United States at a substantial increase in cost.

18. GYPSUM (Data in thousand short tons)

a. Domestic Production and Use:

The United States is the leading producer of gypsum. Gypsum is a common building material in use throughout the world. End uses include walls, partitions, ceilings, cement, agriculture, plaster and wallboard.

b. U.S. Statistics:

	1978
Production	14,700
Imports	7,824
Exports	160
Apparent consumption	22,323
Industry stocks	2,600
Net imports as a percentage of apparent consumption	34%
Import sources 1974-1977:	
Canada	75%
Mexico	18%
Jamaica	4%
Dominican Republic	2%
Others	1%

c. World Production 1978:

	Mine Production	Reserves
United States	14,700	350,000
Canada	8,200	410,000
Iran	7,400	
France	6,400	
Spain	5,000	data
Italy	4,600	not
United Kingdom	3,900	available
West Germany	2,400	
Mexico	1,800	
Other Market Economies	11,500	
Central Economies	9,000	

d. Alternative Sources:

Other construction materials may substitute for gypsum, especially lime, lumber, cement, steel, or masonry. There is no practical substitute for gypsum in portland cement. Byproduct gypsum is presently substituting for crude gypsum in special agricultural applications, and may, in time, be utilized in place of crude gypsum for calcining and manufacture of wallboard.

In an emergency, the U.S. can satisfy all of its import requirements from Western Hemisphere sources.

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19. ILMENITE (Data in thousand short tons of concentrate)

a. Domestic Production and Use:

Six firms produced concentrate from seven operations in New York, Florida, and New Jersey. Two companies produced about 60% of the total. Over 2/3 was mined in Florida and New Jersey. Major coproducts of sand deposits are zircon and rutile; at hardrock deposits, magnetite. Ilmenite and titanium slag were consumed by 15 companies. Five titanium pigment producers used 99% of the total ilmenite and titanium slag consumed. The rest was used in alloys and carbide, welding-rod coatings, ceramics, and chemicals.

b. U.S. Statistics:

	1978
Production	610
Imports for consumption	430
Exports	20
Apparent consumption	998
Industry stocks	910
Net imports as a percentage of apparent consumption	39%
Import sources 1974-1977:	
Canada	52%
Australia	43%
Others	5%

c. World Production 1978:

	Mine Production	Reserves
United States	610	54,000
Australia	1,300	51,000
Canada	940	183,000
Norway	950	154,000
India	150	110,000
South Africa	100	36,000
Other Market Economies	400	19,000
Central Economies	440	15,000

d. Alternative Sources:

Rutile and synthetic rutile are substitutes for ilmenite in the production of titanium dioxide pigment.

The U.S. will continue to depend on Australia, the world's leading producer of ilmenite, for 15 to 20 percent of its total demand for ilmenite. Rutile substitution does not reduce U.S. dependence on Australia, since almost all of the U.S. demand for this metal also is met by imports from Australia.

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20. IODINE (Data in thousand pounds)

a. Domestic Production and Use:

Combined output from the new operation at Woodward, Oklahoma, and the long-established producer of byproduct iodine at Midland, Michigan slightly reduced U.S. reliance on imports. Both producers recovered iodine from subterranean brines. About 31 plants, located primarily in Missouri, New York, New Jersey, and Pennsylvania, reported consumption of domestic and imported crude elemental iodine. The ultimate downstream uses for iodine in 1978 were estimated for the following categories: Catalysts, 22%; animal feed additives, 18%; stabilizers 15%; inks and colorants, 14%; pharmaceuticals, 13%; sanitary and industrial disinfectants, 9%; photographic film, 3%; and other uses, 6%.

b. U.S. Statistics:

	1978
Production	not available
Imports	7,300
Exports	not available
Government sales	0
Apparent consumption	9,000
Industry stocks	unknown
Government stockpile	8,010
Net imports as a percentage of apparent consumption	80%
Import sources 1974-1977:	
Japan	85%
Chile	15%

c. World Production 1978:

	Mine Production	Reserves
United States	not available	not available
Japan	13,000	4,000,000
Chile	4,000	800,000
Central Economies	6,000	not available

d. Alternative Sources:

U.S. resources of iodine in oilfield and natural brines are large but have not been measured precisely. The vast iodine content of seaweed has not been exploited in the U.S. For most of the germicidal and antiseptic properties of iodine, bromine and chlorine could be substituted, although they are usually considered less desirable. Antibiotics and mercurochrome also substitute for iodine as antiseptics and germicidal medicines, and salt crystals and finely divided carbon may be used for cloud seeding.

In an emergency, increased production in Chile and the U.S. and the use of substitutes could make the U.S. independent of sources beyond the Western Hemisphere.

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21. IRON ORE (Data in million long tons)

a. Domestic Production and Use:

Iron ore was produced by 30 companies operating 47 mines, 38 concentration plants, and 19 pelletizing plants. The mines included 42 open pits and five underground mines. Sixteen mines operated by nine companies accounted for 88% of total output. Domestic steel companies controlled U.S. mines responsible for more than 80% of total output. Minnesota produced about 69% of total output, Michigan 21%, and the remainder was produced in nine other States. Consumption of iron ore and agglomerates was distributed as follows: Blast furnaces, 98.7%; steel furnaces 0.5%; and manufacture of cement, heavy media materials and other products, 0.8%.

b. U.S. Statistics:

	1978
Production	80.5
Imports for consumption	33.0
Exports	3.7
Apparent consumption	112.9
Industry stocks	57.0
Net imports as a percentage of apparent consumption	29%
Import sources 1974-1977:	
Canada	50%
Venezuela	25%
Brazil	12%
Liberia	5%
Others	8%

c. World Production 1978:

	Mine Production	Reserves
United States	80.5	17,000
Australia	92.0	17,500
Brazil	88.0	26,800
Canada	45.0	36,000
France	34.0	4,000
India	42.0	9,000
Liberia	18.0	1,400
Sweden	23.0	3,300
Venezuela	14.0	2,600
Other Market Economy Countries	96.5	19,500
Central Economy Countries:		
U.S.S.R.	240.0	109,000
China, People's Republic of	64.0	6,000
Other	23.0	2,200

d. Alternative Sources:

U.S. demand for iron-in-ore is expected to increase from a 1976 base at an average annual rate of about 2% through 1985. Domestic resources are ample to supply forecast demand through 2000, but owing to advantages in price, quality, or transportation costs for some foreign ores, and investments by U.S. companies in foreign mining projects, imports of ore will continue. However, U.S. dependence on imports is declining, and almost all of the sources of U.S. imports are in the Western Hemisphere.

22. LEAD (Data in thousand metric tons)

a. Domestic Production and Use:

The domestic mining industry consists of about 35 mines in 11 States. Fifteen mines produced 99% of the 1978 output. The seven leading mines, all in Missouri, yielded 88% of the year's total mine production of recoverable metal. The balance was supplied by Idaho, 8%; Colorado, 3%; and Utah, 1%. Major coproducts or byproducts were zinc, silver, antimony, and bismuth. Consumption was by about 500 firms in virtually all States. Transportation was the major end use of lead, 51% as batteries and 15% gasoline additives; followed by electrical, 8%; paints, 6%; ammunition, 4%; construction, 3%, and other 13%.

b. U.S. Statistics:

	1978
Production	531
Imports for consumption	296
Exports	126
Government sales	0
Apparent consumption	1350
Industry stocks	109
Government stockpile	545
Net imports as a percentage of apparent consumption	11%
Import sources 1974-1977:	
Canada	30%
Mexico	20%
Peru	18%
Australia	11%
Others	21%

c. World Production 1978:

	Mine Production	Reserves
United States	531	26,000
Australia	370	17,000
Canada	360	12,000
Peru	190	4,000
Mexico	160	5,000
Other Latin America	105	5,000
Other Market Economies	670	27,000
Central Economies	1,100	30,000

d. Alternative Sources:

Within the last 5 years major new discoveries of identified, economic and selected marginal resources of lead have been made in the United States, Canada, Australia, and the Republic of South Africa. Total identified, subeconomic lead resources of the world are currently estimated at about 1.4 billion tons. Much of this resource, however, is in low-tenor or unconventional deposits that will need new technologies for exploration and recovery. Meanwhile the prospect for the discovery of additional reserves and resources of conventional ores at a rate that exceeds consumption is highly favorable. Substitution by plastics has reduced the use of lead in building construction, electrical cable covering, and in cans and containers. Lead also competes with other metals for use in construction, packaging, and protective coatings. Nickel-cadmium and silver-zinc are among alternate materials for lead in batteries.

During World War II and in 1951 to 1952, the U.S. Government regulated the lead industry to provide adequate supplies for all essential purposes. Transportation facilities to Canada and Mexico, the major sources of imported metal, are readily available. Primary and secondary lead smelting facilities are well dispersed and remote from industrial and military targets. Producing mines are underground, and reserves are adequate for major expansion of output if necessary.

23. MANGANESE (Data in thousand short tons gross weight)

a. Domestic Production and Use:

Manganese is essential to the production of virtually all steels. It is also important to the production of pig iron, aluminum, dry cell batteries, and in various chemical processes. In 1978, the U.S. produced no manganese ore that contained 35% or more manganese. A small amount of manganiferous ore - about 2% of apparent consumption - containing less than 35% manganese was produced domestically. Except for Government stock releases, the U.S. depends almost exclusively upon foreign supplies of manganese.

b. U.S. Statistics:

	1978	
	Manganese Ore	Ferromanganese
Mine production	28	0
Imports for consumption	600	675
Exports	130	6
Government stockpile sales	330	0
Apparent consumption of elemental Mn	1,415	
Industry stocks	1,200	250
Government stockpile	4,127	653
Net import reliance as a percentage of apparent consumption	98%	
Import sources 1974-1977:		
Gabon	36%	
Brazil	33%	
Australia	13%	
South Africa	9%	30%
France		32%
Japan		14%
Other	9%	24%

c. World Production 1978: (35% or more Mn content)

	Mine Production	Reserves
United States	0	0 0
South Africa	5,800	2,200,000
Gabon	2,100	165,000
India	2,000	65,000
Australia	1,700	330,000
Brazil	1,200	95,000
Other Market Economies	1,500	59,000
Central Economies	10,700	3,000,000

The U.S.S.R. and South Africa hold more than 80% of the world's known resources. In addition, large areas of the ocean floors, particularly in the e quatorial Pacific Ocean, contain deposits of manganese oxide. Currently, the economic and political feasibility of manganese recovery from ocean floor deposits has not been demonstrated.

d. Alternate Sources:

The U.S. has no reserves containing at least 35% manganese. The domestic resources of 74 million tons of contained manganese are in low grade ore that is expensive to mine. A lead time of 3 years is needed to build the industry that could produce manganese from domestic resources.

The use of manganese is correlated to the production of iron and steel. As the production of steel increases in wartime, so does the consumption of manganese. No short term alternatives to importing manganese exist. Brazil and Australia have the production capacity to supply U.S. demand. At a minimum, the sea lanes from Australia to America must be protected to guarantee the availability of manganese to the U.S. in wartime.

24. MERCURY (Data in 76 pound flasks of metal)

a. Domestic Production and Use:

The producing industry was composed of one operation in Nevada producing refined mercury at the mine site. A small amount of mercury was recovered as a byproduct of gold refining. Some 65 firms in the Eastern United States were the principal consumers. Uses were electrical apparatus, 45%; electrolytic preparation of chlorine and caustic soda, 19%; mildew-proofing paint, 17%; industrial and control instruments, 6%; and other applications, 13%.

b. U.S. Statistics:

	1978
Production	32,100
Imports for consumption	35,000
Exports	1,000
Apparent consumption	70,100
Industry stocks	18,900
Government stockpile	191,587
Net imports as a percentage of apparent consumption	57%
Import sources 1974-1977:	
Algeria	23%
Canada	20%
Spain	14%
Mexico	11%
Yugoslavia	11%
Others	21%

c. World Production 1978:

	Mine Production	Reserves
United States	35,000	350,000
Spain	35,000	1,500,000
Algeria	25,000	350,000
Mexico	15,000	250,000
Other Market Economies	5,000	350,000
Central Economies	85,000	1,500,000

d. Alternative Sources:

Imports provide a substantial part of U.S. demand primarily because of the competitive advantages of foreign production. In an emergency, the U.S. stockpile and increased production of Western Hemisphere sources would be adequate to meet U.S. demand.

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25. MICA (Sheet) (Data in thousand pounds)

a. Domestic Production and Use

Because of its dielectric and insulating properties, sheet mica is used in manufacturing electrical and electronic equipment, principally as vacuum tube spacers. High quality mica is used to line gage glasses of steam boilers and as diaphragms for oxygen breathing equipment. Other uses include marker dials for navigation compasses, quarter-wave plates in optical instruments, pyrometers, thermal regulators, and microwave oven windows.

The small amount of sheet mica produced in the U.S. recently is insignificant when compared to total demand and world production. U.S. consumption has declined since 1960 and will continue to decrease at about 4% per year until at least 1985. This decline is attributable to the increase in solid state devices that have supplanted vacuum tubes and the availability of mica based and non-mica substitutes.

b. U.S. Statistics:

	1978
Mine production	1
Imports for consumption	4,500
Exports	2,000
Government stockpile sales	809
Apparent consumption	3,310
Industry stocks	3,500
Government stockpile:	
Muscovite block	5,108
Muscovite film	1,273
Muscovite splittings	21,982
Phlogopite block	131
Phlogopite splittings	2,821
Net import reliance as a percentage of apparent consumption	100%
Import sources 1974-1977:	
India	74%
Brazil	20%
Malagasy Republic	3%
Other	3%

c. World Production 1978:

	Mine Production	Reserves (estimated)
United States	1	small
India	40,000	very large
Brazil	1,000	large

Malagasy Republic	160	large
Other Market Economies	3,300	moderate
Central Economies	3,000	large

Because of the sporadic occurrence of sheet mica, no formal evaluation of world resources has ever been made. India, Brazil and the Malagasy Republic have the largest known deposits. The very limited domestic resources currently are not economical to mine, because mining and processing is labor intensive.

d. Alternative Sources:

The U.S. can not become self-sufficient in the production of sheet mica. However, the relatively large U.S. government stockpile, the feasibility of increasing imports from Brazil, and the decreasing demand for mica are all factors sufficient to preclude the need to import from India during a national emergency. Therefore the U.S. does not have to protect any transoceanic sea lanes, in wartime, to insure the availability of enough mica for its industry.

26. NICKEL (Data in thousand short tons of metal)

a. Domestic Production and Use:

One firm in Oregon mined nickel ore and produced ferronickel. A second firm in Louisiana produced nickel metal from imported intermediate (matte) materials. Nickel was also produced as a byproduct of copper refining and from secondary sources. Secondary nickel was recovered from nickel-bearing alloys, stainless and alloy steel, and residues at copper smelters and refineries, foundries, and steel mills. At the foundries and steel mills, nickel was normally used in the form in which it was recovered. However, there were several companies involved in the melting down of obsolete mixed scrap. The principal forms of primary nickel consumed were: Pure nickel metal, ferronickel, nickel oxide, and nickel salts. Major industrial consumers totaled about 200 with the largest ones in Pennsylvania, West Virginia, Ohio, Illinois, Michigan, Maryland, and New York. Nickel was consumed in the production of stainless and alloy steels, 44%; nonferrous alloys, 33%; and electroplating, 17%. Ultimate major end uses were: Transportation, 23%; chemical industry, 15%; electrical equipment, 13%; construction and fabricated metal products, 9% each; other, 31%. The estimated value of primary nickel consumed in 1978 was $760 million.

b. U.S. Statistics:

	1978
Production:	
Mine	12
Plant	38
Byproduct	1
Secondary	40
Imports for consumption	231
Exports	28
Apparent consumption	233
Industry stocks	128
Government stockpile	0
Net imports as a percentage of apparent consumption	77%
Import sources 1974-1977:	
Canada	58%
Norway (from Canada)	7%
New Caledonia	7%
Dominican Republic	7%
Others	21%

c. World Production 1978:

	Mine Production	Reserves
United States	12	200
Canada	182	8,600
New Caledonia	70	15,000
Cuba	38	3,400
Other Market Economies	198	28,000
Other Central Economies	150	4,800

d. Alternative Sources:

Although nickel demand increases in wartime, the combined production capacities of the U.S. and Canada are sufficient to meet U.S. demand in an emergency. To insure a supply of nickel for defense needs, the U.S. Department of Commerce, in 1966, directed the three major suppliers to set aside 25% of monthly shipments for defense orders. The set aside program is still in effect, although the percentage was changed to 10% in 1975, and the number of companies involved increased to five.

27. PEAT (Data in thousand short tons)

a. Domestic Production and Use:

Peat is partially decomposed plant matter that has accumulated underwater or in a water saturated environment. It is the initial stage in the formation of coal from vegetable materials. Virtually all peat consumed in the U.S. is used in agriculture and horticulture as a soil improvement agent.

b. U.S. Statistics:

	1978
Production	840
Imports for consumption	370
Apparent consumption	1,170
Industry stocks	not available
Net imports as a percentage of apparent consumption	32%
Import sources 1974-1977:	
Canada	97%
West Germany	3%

c. World Production 1978:

	Mine Production	Reserves
United States	840	
Canada	450	not
West Germany	2,700	available
Ireland	7,000	
Finland	700	
Netherlands	500	
Other Market Economies	700	
Central Economies	220,000	

d. Alternative Sources:

Straw, tree bark and other fibrous plant materials can be used as a substitute for peat. However, U.S. demand can be met by domestic and Canadian sources indefinitely.

28. PLATINUM GROUP METALS (Data in thousand troy ounces)
(Platinum, Palladium, Iridium, Osmium, Rhodium, Ruthenium)

a. Domestic Production and Use:

The platinum group metals, also known as precious, or noble, metals, are among the scarcest of the metallic elements. Their properties of refraction, inertness, catalytic action and thermal stability make them useful in the following end uses: Automobile catalytic converters, 37%; petro-chemical industry, 28%; electronics, 20%; dentistry and medicine, 8%; jewelry and other uses, 7%. U.S. production from primary and secondary sources amounts to less than 9% of apparent consumption.

b. U.S. Statistics:

	1978
Mine production	5
Secondary from scrap	200
Imports for consumption	2,700
Exports	700
Government stockpile sales	0
Apparent consumption	2,318
Industry stocks	900
Government stockpile:	
Platinum	453
Palladium	1,253
Iridium	17
Net imports as a percentage of apparent consumption	91%
Import sources 1974-1977:	
South Africa	42%
U.S.S.R.	26%
United Kingdom (from S. Africa & Canada)	17%
Canada	3%
Other	12%

c. World Production 1978:

	Mine Production	Reserves
United States	5	1,000
U.S.S.R.	3,000	200,000
South Africa	2,950	580,000
Canada	390	9,000
Colombia	25	1,000
Other Market Economies	30	not available

d. Alternative Sources:

Almost all of the world's supply of platinum group metals comes from South Africa, the U.S.S.R. and Canada. U.S. imports amounting to a third of world production are vulnerable to actions of the governments of foreign suppliers. Although the U.S. has large resources - 210 million troy ounces - mostly in Montana and Alaska, they are undeveloped, not well defined and not economically recoverable at current prices. The domestic mine supply could not be increased rapidly if foreign supplies were cut. Consequently, the U.S. would continue to rely on its major source in wartime and would have to protect the sea lanes from South Africa across the Atlantic Ocean. It is conceivable that the total annual imports of 2.7 million troy ounces, or 93 tons, could be moved by air, thereby eliminating the need to protect any sea lanes for this commodity.

29. POTASSIUM (Data in thousand metric tons K_2O equivalent)

a. Domestic Production and Use:

Potash from U.S. mines supplied U.S. demand until 1962. Since then, production has remained constant and increased demand has been met by imports. The value of U.S. production of marketable potash salts, f.o.b. mine, in 1978 was about $230 million. Potash production was centered in eastern New Mexico, where seven companies, operating eight mines by conventional mining of bedded deposits, produced 85% of the U.S. total. One mine in Utah recovered potash by dissolving it in water underground and pumping it to the surface for recovery. Two plants in Utah and one in California recovered potash from salt lakes or natural brines. Ten companies comprise the domestic industry; nine had one operation each, and one had both a mine in New Mexico and the plant in California. Borax, sodium carbonate, lithium, bromine, and sodium sulfate were recovered as coproducts from brines in California, and sodium sulfate, sodium chloride, and magnesium compounds from brines in Utah. Most potash was produced as the chloride, KCl (known commercially as potassium muriate), but is reported in terms of the oxide, K_2O. About 95% of the total output was used directly in the fertilizer industry; potassium sulfate and potassium magnesium sulfate, produced for special crops, comprised about one-sixth of total potash production. Over 5,000 plants produced fertilizers by mixing and blending the chief fertilizer materials, including potash; the plants were located in all States, but were concentrated in north central farming areas.

b. U.S. Statistics:

	1978
Mine production	2,268
Imports for consumption	4,536
Exports	844
Apparent consumption	5,876
Industry stocks	551
Government stockpile	0
Net imports as a percentage of apparent consumption	61%
Import sources 1974-1977:	
Canada	95%
Israel	2%
West Germany	1%
Other	2%

c. World Production 1978:

	Mine Production	Reserves
United States	2,268	200,000
Canada	5,930	10,000,000
West Germany	2,320	200,000
France	1,680	40,000
Other Market Economies	1,670	460,000
Central Economies	12,300	2,300,000

d. Alternative Sources

The leading producer of potash, Canada, can meet U.S. import demand indefinitely. Alternative sources are unnecessary.

30. QUARTZ CRYSTALS (Data in thousand pounds)

a. Domestic Production and Use:

The U.S. does not produce natural quartz crystals suitable for electronic applications. Lasca, the feedstock material for making cultured quartz is imported almost exclusively from Brazil. In addition to the traditional uses of oscillators, filter plates, and telephone resonators, quartz crystals are now used in clocks and watches due to their high accuracy.

b. U.S. Statistics:

	1978
Production:	
Mine	0
Cultured	385
Imports for consumption	585
Exports	not available
Government Sales	104
Apparent consumption	not available
Industry stocks	not available
Government stockpile	2,694
Net imports as a percentage of apparent consumption (lasca)	100%
Import sources 1974-1977:	
Brazil	96%
Others	4%

c. World Production 1978:

	Mine Production	Reserves
United States	0	small
Brazil	500	large
Other Market Economies	negligible	small
Central Economies	not available	not available

d. Alternative Sources:

The U.S. Government stockpile is sufficient for several years of demand. Until domestic sources of silica suitable for use in producing cultured quartz are identified, the U.S. is almost totally dependent for lasca on Brazil, which fortunately is in the Western Hemisphere.

31. RHENIUM (Data in pounds of metal)

a. Domestic Production and Use:

In 1978, rhenium was recovered as a byproduct from roasting molybdenite concentrate from domestic southwestern porphyry copper ores. One rhenium producer operated during the year and accounted for all U.S. production. The main application for rhenium was in bimetallic platinum-rhenium catalysts used to produce low-lead and lead-free high-octane gasoline, 92%; other applications (includes x-ray tubes and targets, flashbulbs, vacuum tubes, metallic coatings, and research and development), 6%; and instruments (includes thermocouples, temperature controls, and heating elements, 2%.

b. U.S. Statistics:

	1978
Production	not available
Imports for consumption	8,000
Exports	0
Apparent consumption	8,000
Industry stocks	20,000
Net imports as a percentage of apparent consumption	100%
Import sources 1974-1977:	
West Germany	47%
Chile	45%
Sweden	8%

c. World Production 1978:

	Mine Production	Reserves
United States	not available	2,600,000
Canada	3,800	700,000
Chile	5,000	2,600,000
Peru	400	400,000
U.S.S.R.	2,000	500,000
Others	200	200,000

d. Alternative Sources:

The U.S. could be self-sufficient in rhenium if the economic incentives existed. Since rhenium is obtained from molybdenite of porphyry copper operations, its resources are closely related to resources of molybdenum in porphyry copper deposits. Identified U.S. resources of rhenium are estimated to be about 10 million pounds, and identified world resources are on the order of 22 million pounds. Although other sources exist, they are not known to be significant.

Substitutes for rhenium in platinum-rhenium catalysts are being evaluated continually. Iridium has achieved commercial success in one such application. Other metals being evaluated for catalytic use include gallium, germanium, indium, selenium, silicon, tin, tungsten, and vanadium. The use of these and other metals in bimetallic catalysts may tend to erode rhenium's share of the catalyst market in the long run. Materials that can substitute for rhenium in various end uses are: cobalt and tungsten for coatings on copper x-ray targets, rhodium and rhodium-iridium for high-temperature thermocouples, tungsten and platinum-ruthenium for coatings on electrical contacts, and tungsten and tantalum for electron emitters.

In any case, the amount of rhenium imported does not require sea lane transportation, and Western Hemisphere sources are adequate to meet U.S. wartime demand.

32. RUTILE (Data in thousand tons of concentrate)

a. Domestic Production and Use:

Rutile concentrate was produced at one Florida mine until June 30. At three other mines in Florida, rutile was included in a bulk concentrate containing mostly ilmenite and/or leucoxene. The major coproduct of these titanium minerals is zircon. One company in Alabama produced synthetic rutile from imported ilmenite during January and February. Of 33 consuming firms located mainly in the Eastern United States, five companies used 83% of the rutile consumed to make titanium dioxide pigment. Three firms in Nevada, Ohio, and Oregon used titanium tetrachloride made from rutile to manufacture titanium metal. Welding rod coatings consumed 4%; miscellaneous applications, which include metal and glass fibers, 13%.

b. U.S. Statistics:

	1978
Production	6
Imports for consumption	250
Exports	0
Government sales	0
Reported consumption	280
Industry stocks	100
Government stockpile	39
Net imports as a percentage of apparent consumption	90%
Import sources:	
Australia	86%
Japan	8%
India	4%
Others	2%

c. World Production 1978:

	Mine Production	Reserves
United States	6	3,000
Australia	300	10,000
Brazil	0	100,000
India	7	8,000
Sierra Leone	0	3,000
South Africa	20	2,000
Other Market Economies	1	5,000
Central Economies	30	3,000

d. Alternative Sources:

Ilmenite, titaniferous slag, and synthetic rutile made from ilmenite may be used instead of natural rutile for making pigment or welding rod coatings. However, the U.S. depends on imports of ilmenite from Australia as well.

33. SCANDIUM (Data in kilograms of metal)

a. Domestic Production and Use:

No production of scandium from domestic sources was reported in 1978. Production at one refinery was derived from imports or materials held in stocks. About 13 companies purchased or sold scandium materials. Scandium was mostly used in investigations by research laboratories. It has two established commercial uses - - in special high-intensity lamps (scandium iodide) and as a tracer in petroleum production (radioisotope Sc-46). Some scandium was consumed by the chemical and electronic industries. Demand was small and was expressed in kilograms.

b. U.S. Statistics:

	1978
Production	0
Imports	no data
Exports	no data
Apparent consumption	15
Net imports as a percentage of apparent consumption	100%
Import sources 1974-1977:	
Australia	percent unknown
U.S.S.R.	percent unknown
United Kingdom	percent unknown

c. World Production 1978:

The U.S.S.R. is the world's principal producer of scandium. Australia has a stockpile to meet world demand for about 5 years.

d. Alternative Sources:

Large supplies of scandium are available from domestic uranium, tungsten and phosphate resources. Substitutes are rare earths and yttrium.

34. SELENIUM (Data in thousand pounds)

a. Domestic Production and Use:

Selenium production during 1978 decreased 8% to 460,000 pounds, imports increased 54% over 1977, and producers' stocks increased by 137,000 pounds. All reported primary selenium production was recovered as a byproduct during the processing of electrolytic copper refinery slimes to recover gold and silver. Tellurium is also recovered from these slimes by additional processing. Three copper refineries, located in New Jersey, Texas, and Utah, accounted for all of the domestic production of selenium. Slimes from copper refineries owned by other companies are shipped to these plants for recovery of gold, silver, selenium, and tellurium. A small amount of scrap selenium was recovered by two companies located in the Northeastern United States. More than 200 firms in widely scattered locations are domestic consumers. Major uses were in electronic and photocopier components, 35%; glass manufacturing, 30%; chemicals and pigments, 25%; and other, 10%.

b. U.S. Statistics:

	1978
Production	460
Imports for consumption	900
Exports	150
Government sales	0
Apparent consumption	1,100
Industry stocks	460
Net imports as a percentage of apparent consumption	61%
Import sources 1974-1977:	
Canada	61%
Japan	14%
Yugoslavia	7%
Mexico	5%
Others	13%

c. World Production 1978:

	Production	Reserves
United States	460	86,000
Japan	1,000	2,000
Canada	450	28,000
Sweden	155	2,000
Benelux	130	not available
Mexico	130	12,000
Yugoslavia	100	5,000
Peru	40	28,000
Chile	35	86,000
Finland	30	1,200
Others	not available	190,000

d. Alternative Sources:

U.S. production capacity is sufficient to meet U.S. demand, given the proper economic incentives. Currently, about 2/3 of imports come from the Western Hemisphere. Hence no transoceanic sea lanes are needed to meet the U.S. demand for selenium.

35. SILICON (Data in thousand short tons of contained silicon)

a. Domestic Production and Use:

Silicon, combined with oxygen, is the second most abundant element in the earth's crust. Silicon's low cost and almost limitless resources mean that no supply-demand problems should occur in the future. The main consumers of silicon metal are aluminum alloy producers located throughout the United States. The end uses of silicon were: transportation, 37%; machinery, 21%; construction, 13%; chemicals, 8%; and other, 21%.

b. U.S. Statistics:

	1978
Production	530
Imports for consumption	125
Exports	5
Apparent consumption	647
Industry stocks	120
Government stockpile	80,364
Net imports as a percentage of apparent consumption	18%
Import sources 1974-1977:	
Norway	31%
Canada	17%
France	9%
Yugoslavia	8%
Other	35%

c. World Production 1978:

	Production	Reserves
United States	530	
Norway	280	ample
Japan	220	everywhere
France	180	
South Africa	115	
Canada	90	
Italy	75	
West Germany	70	
Sweden	40	
India	30	
Other Market Economies	170	
Central Economies	700	

d. Alternative Sources:

The main reason that the U.S. imports silicon is that smelting costs in some countries are lower than domestic smelting costs. The U.S. as the world's leading producer of silicon with an almost limitless supply would be self-sufficient in wartime.

36. SILVER (Data in million troy ounces)

a. Domestic Production and Use:

Nearly one third of newly mined silver is obtained from silver ores. The balance is derived from copper, lead, zinc and other mineral production. Most of the mines and smelters are in the Western States. End uses are photography, 38%; electrical and electronic components, 26%; sterling and electroplated ware, 17%; brazing alloys and solders, 7%; and others, 12%.

b. U.S. Statistics:

	1978
Production:	
Mine	38
Refinery	97
Imports for consumption	80
Exports	21
Government sales	0
Apparent consumption	135
Industry stocks	165
Government stockpile	140
Net imports as a percentage of apparent consumption	41%
Import sources 1974-1977:	
Canada	37%
Mexico	24%
Peru	15%
United Kingdom	6%
Others	18%

c. World Production 1978:

	Mine Production	Reserves
United States	38	1,510
Mexico	50	850
Canada	41	710
Peru	35	610
Other Market Economies	100	420
Central Economies	70	2,000

d. Alternative Sources:

Aluminum and rhodium substitute for silver in mirrors and other reflecting surfaces. Tantalum can be used in place of silver for surgical plates, pins, and sutures. Stainless steel is an alternate material used widely in the manufacture of table flatware.

In an emergency almost all of the import demand of the U.S. can be met by Western Hemisphere sources. Since silver production is largely dependent on the production of other metals, the output is determined chiefly by economic factors affecting metals other than silver.

37. STRONTIUM (Data in short tons contained strontium)

a. Domestic Production and Use:

Principal uses of strontium are as a radiation shield in the manufacture of color television picture tube glass (65%), pyrotechnics (15%), ferrite ceramic permanent magnets (5%), and others (15%). Among the other uses are zinc refining, ceramic glazes, greases, paints and welding rod coatings. Since 1959, no strontium or strontium compounds have been produced in the U.S.; the U.S. relies on imports for 100% of its apparent consumption.

b. U.S. Statistics:

	1978
Mine production	0
Imports	19,700
Exports	not available
Government stockpile sales	0
Apparent consumption	19,700
Industry stocks	not available
Government stockpile	5
Net import reliance as a percentage of apparent consumption	100%
Import sources 1974-1977:	
Mexico	90%
Spain	10%

c. World Production 1978:

	Mine Production	Reserves
United States	0	
Mexico	20,500	(Large unquantified foreign reserves)
Spain	3,400	
United Kingdom	2,500	
Algeria	2,300	
Argentina	1,000	
Italy	300	
Other Market Economies	500	
Central Economies	900	

d. Alternative Sources:

The latest estimate of U.S. strontium resources is 3.5 million tons of ore containing about 3 million tons of strontium sulfate. Recently developed deposits in Mexico and Canada are known to be large and probably sufficient to meet U.S. demand in the event that overseas sources are not available. Transoceanic sea lanes are not needed to supply U.S. demand.

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38. TANTALUM (Data in thousand pounds tantalum content)

a. Domestic Production and Use:

The tantalum capacitor sets the standard in the electronics industry. Other major applications are in high temperature alloys, corrosion resistant alloys with aerospace and nuclear applications, machine cutting tools, aircraft, missiles, and radio communications. Demand for tantalum has increased sharply whenever the U.S. was involved in a military conflict. Tantalum has not been mined domestically since 1959.

b. U.S. Statistics:

	1978
Mine production	0
Imports for consumption	1,750
Exports	590
Government stockpile sales	0
Apparent consumption	1,660
Industry stocks	3,650
Government stockpile:	
Carbide powder	29
Metal	201
Minerals	2,551
Net imports as a percentage of apparent consumption	97%
Import sources 1974-1977:	
Thailand	36%
Canada	16%
Malaysia	9%
Brazil	9%
Zaire	5%
Australia	5%
Other	20%

c. World Production 1978:

	Mine Production	Reserves
United States	0	0
Canada	250	2,000
Brazil	150	7,000
Nigeria	150	16,000
Australia	110	5,000
Mozambique	80	not available
Zaire	50	82,000
Thailand	20	10,000
Malaysia	15	8,000
Other Market Economies	55	4,000
Central Economies	not available	not available

d. Alternative Sources

The U.S. has about 3.4 million pounds of identified tantalum deposits that are not economically recoverable at 1978 prices. During an emergency, the U.S. could obtain an adequate supply of tantalum by developing these deposits. In addition, the production capacity in the Western Hemisphere - mainly in Canada and Brazil - eliminates the need to use transoceanic sea lanes for tantalum imports.

39. TELLURIUM (Data in thousand pounds of metal)

a. Domestic Production and Use:

Tellurium is recovered as a byproduct of the electrolytic refining of copper. During the processing of copper tankhouse sludges for gold and silver, a selenium-tellurium fraction is separated from the sludge. After recovery of the selenium from this fraction, the remaining material containing tellurium is refined as needed to supply markets. Production and shipments in 1978 were from two refineries located in New Jersey and Texas. Tellurium is used in its elemental state as a free-machining agent in alloys with steel and copper, in the chilling of malleable cast iron, and as a curing agent and accelerator in rubber compounding. Bismuth and lead telluride alloys are used in semi-conductor and minor thermoelectric applications. Tellurium is used as the dioxide in the forming and tinting of glass and as a chemical catalyst. Consumption by major use is estimated as follows: iron and steel products, 77%; nonferrous metal products, 14%; chemicals, 5%; and other 4%.

b. U.S. Statistics:

	1978
Production	not available
Imports for consumption	180
Exports	not available
Apparent consumption	not available
Net imports as a percentage of apparent consumption	20%
Import sources 1974-1977:	
Canada	54%
Peru	27%
Others	19%

c. World Production 1978:

	Production	Reserves
United States	not available	21,000
Canada	120	7,000
Japan	160	not available
Peru	50	7,000
Others	not available	87,000

d. Alternative Sources:

The chief materials which can substitute for, or replace tellurium include selenium, bismuth, and lead in metallurgical applications, selenium and sulfur in rubber compounding and chemical applications, and selenium and germanium in electronic applications.

Almost all of U.S. import demand, in a crisis, could be met by Western Hemisphere sources.

40. THALLIUM (Data in pounds of metal)

a. Domestic Production and Use:

Thallium and thallium compounds were produced domestically by one company located in Colorado. Thallium is a minor byproduct produced from flue dusts and residues collected in the smelting of copper, zinc, and lead ores. It is marketed as powdered thallium sulfate, or as metal in the form of sticks, ingots, or wire. The electronics industry consumed about 60% to 70% of the thallium sold in 1978. A small amount of thallium was also consumed as a radioactive isotope in a new technique for diagnosing heart disease. The balance was used in pharmaceuticals, alloys, glass manufacturing, and miscellaneous minor uses.

b. U.S. Statistics:

	1978
Production	not available
Imports for consumption	300
Exports	not available
Apparent consumption	1,500
Net imports as a percentage of apparent consumption	20%
Import sources 1974-1977:	
U.S.S.R.	52%
West Germany	35%
Benelux	7%
Others	6%

c. World Production 1978:

U.S. and world production statistics are not available for recent years.

d. Alternative Sources:

U.S. production capacity far exceeds projected future demand. While other materials can be substituted for thallium and its compounds in specific applications, ample supplies militate against intensive development of substitute and alternate materials.

41. THORIUM (Data in short tons of ThO_2)

a. Domestic Production and Use:

Production of thorium is derived from monazite, a byproduct of titanium recovery from beach sands. Although monazite was produced for its rare-earth and yttrium content by two companies in Florida, thorium products were not produced from monazite in the United States. One facility, in Tennessee, stored thorium-containing residues resulting from the production of rare earths from domestic and imported monazite. Thorium products used by the domestic industry came from imports, industry, and Government stocks. About 14 companies processed or fabricated thorium, including nuclear reactor fuels. Thorium was used as the metal, oxide, nitrate, and chloride. Nonenergy uses valued at approximately $0.5 million were as a constituent of mantles for incandescent lamps, 60% to 70% of the total, and in magnesium-thorium alloys, refractories, and other applications, the remaining 30% to 40%. Thorium also was used as nuclear fuel in a commercial electric generating plant and in experimental reactors.

b. U.S. Statistics:

	1978
Production	0
Imports	34
Exports	0
Government sales	0
Apparent consumption	4
Industry stocks	not available
Government stockpile	1,675
Net imports as a percentage of apparent consumption	100%
Import sources 1974-1977:	
France	95%
Others	5%

c. World Production 1978:

Production statistic for recent years are not available. World reserves are about 790,000 short tons.

d. Alternative Sources:

No satisfactory alternative materials are suitable for major non-energy uses of thorium.

Since thorium is the byproduct of titanium derived from beach sands, its supply has exceeded demand for many years. The U.S. has a large surplus. Thorium is imported only because of economic price considerations.

42. TIN (Data in metric tons of metal)

a. Domestic Production and Use:

Tin is essential to an industrial society, and there are no satisfactory substitutes in many applications. Tin is used in cans and containers, solder, bearing alloys, collapsible tubes, pewterware and pipes in food processing. The U.S. is the world's major consumer of tin. But domestic resources are negligible and increases in production beyond about 20% of demand are unlikely. The only tin smelter in the U.S. at Texas City, Texas, processed 4,000 tons of Bolivian concentrates in 1978. The other U.S. production of 19,500 tons came from secondary materials.

b. U.S. Statistics:

	1978
Production:	
Mine	company confidential
Smelter	4,000
Secondary	19,500
Imports for consumption	51,500
Exports	5,100
Government stockpile sales	345
Apparent consumption	59,400
Industry stocks	17,000
Government stockpile	203,691
Net imports as a percentage of apparent consumption	81%
Imports sources 1974-1977:	
Malaysia	49%
Bolivia	16%
Thailand	14%
Indonesia	9%
Other	12%

c. World Production 1978:

	Mine Production	Reserves
United States	company confidential	40,000
Malaysia	60,000	830,000
U.S.S.R.	33,000	620,000
Bolivia	30,000	980,000
Indonesia	26,000	2,400,000
Thailand	26,000	1,200,000
P.R.C.	20,000	1,500,000
Australia	11,600	330,000
Brazil	7,000	600,000
Nigeria	3,500	280,000

United Kingdom	3,000	260,000
Zaire	3,000	200,000
Burma	800	500,000
Other	11,100	260,000

d. Alternative Sources:

No major shift of U.S. supply sources is anticipated. If current supplies are curtailed, the Government strategic stockpile is sufficient for about 3 years of current peacetime consumption. The only Western Hemisphere sources, Bolivia and Brazil, produce 16%, and the U.S. imports 22%, of world production. If these Western Hemisphere sources could increase production capacity during the 3 years that the U.S. relied on its Government stockpile in a crisis, it is conceivable that subsequent U.S. import demand could be met by Bolivia and Brazil. Otherwise, the sea lanes to Australia would have to be protected to insure the availability of additional tin imports needed to satisfy U.S. demand.

43. TITANIUM (Data in short tons of metal)

a. Domestic Production and Use:

The mineral sources of titanium products are ilmenite and rutile (see ILMENITE and RUTILE sections). Sponge metal was produced by three firms in plants in Ohio, Oregon, and Nevada with more than 50% of the production in Nevada. Ingot was made by the three sponge makers and by five other firms located in California, Michigan, North Carolina, and Pennsylvania. Sixteen companies produced titanium mill products with 10 of them being located in the east-central region and the others in California, Oregon, and Nevada. In 1978, about 60% of the titanium metal was used in jet engines, airframes, and space and missile applications. Of the remainder, about half was used in the chemical processing industry, power generation, and in marine and ordnance applications, and half in steel and other alloys.

b. U.S. Statistics:

	1978
Production	not available
Imports for consumption	1,800
Exports (mostly scrap)	6,800
Government sales	0
Reported consumption	19,000
Industry stocks	2,600
Government stockpile	21,465
Net imports as a percentage of apparent consumption	(see ilmenite & rutile)

c. World Production 1978:

	Production	Capacity
United States	not available	23,500
Japan	9,000	12,500
Other Market Economies	2,400	4,000
Central Economies	39,000	42,000

d. Alternative Sources:

For aircraft and space uses there is essentially no substitute for titanium. For industrial uses high-nickel steel and to a limited extent the superalloy metals may be substituted.

U.S. dependence on foreign sources is a function of U.S. dependence on ilmenite and rutile imports, mainly from Australia.

44. TUNGSTEN (Data in thousand pounds tungsten content)

a. Domestic Production and Use:

Tungsten has the highest melting point of all metals, has good corrosion resistance and out ranks all metals in tensile strength. End uses of tungsten were metalworking and construction machinery, 75%; transportation, 11%; lamps and lighting, 7%; electrical, 4%; other, 3%.

Almost 97% of domestic tungsten production came from four mines in California, Oregon and Nevada.

b. U.S. Statistics:

	1978
Production	7,200
Imports for consumption	8,900
Exports	2,300
Government sales	5,400
Apparent consumption	20,500
Industry stocks	1,000
Government stockpile (all types)	71,000
Net imports as a percentage of apparent consumption	50%
Import sources 1974-1977:	
Canada	22%
Bolivia	16%
Peru	12%
Thailand	10%
Many Others	40%

c. World Production 1978:

	Mine Production	Reserves
United States	7,200	275,000
Australia	5,500	170,000
Austria	1,000	40,000
Bolivia	6,600	87,000
Brazil	2,500	40,000
Burma	1,000	70,000
Canada	4,000	476,000
South Korea	5,500	100,000
Mexico	500	44,000
Portugal	2,200	54,000
Thailand	5,000	40,000
Turkey	3,000	170,000
Other Market Economies	8,000	50,000
Central Economies	43,000	2,800,000

d. Alternative Sources:

More than 90% of the world's estimated tungsten resources are located outside the United States, with almost 50% located in southeastern China. Other areas with significant resource potential are in Canada, North Korea, South Korea, South America, Burma, Malaysia, Thailand, Australia, Portugal, Austria, Mexico, Turkey, and the U.S.S.R. United States tungsten resources are conservatively estimated at about two and a half times the reserves. These potential U.S. resources include numerous identified subeconomic deposits, Searles Lake, California, brines, and possible pyproduct production from large scale mining operations for other commodities.

Titanium carbide, tantalum carbide, and columbium carbide can be substituted for tungsten in some wear-resisting applications. Also, molybdenum is being substituted for tungsten in tool steels. In many cutting tool applications, depending on factors such as material, feed speed, and depth of cut, some economical substitutes for tungsten carbide are bulk ceramics and coatings of carbides, nitrides, carbonitrides, and alumina on tungsten carbide inserts.

The supply of tungsten for long range U.S. demand has not been developed, and the ability of U.S. producers to meet emergency demands for tungsten is not known fully.

However, in a mobilization period, tungsten could be supplied by domestic producers, by imports from Canada, Mexico and other countries in the Western Hemisphere and by materials from the Government stockpile. A shortage would not occur for three years.

45. VANADIUM (Data in thousand pounds of contained vanadium)

a. Domestic Production and Use:

Three firms produced vanadium oxides in 1978 from domestic materials; a fourth company recovered vanadium oxide solely from foreign materials. Colorado Plateau uranium-vanadium ores and tailings, Arkansas vanadium ore, and Idaho ferro-phosphorus were the domestic materials processed for recovery of vanadium oxide. The chief use of vanadium was as an alloying agent for iron and steel, to which it was added mainly in the form of ferrovanadium or proprietary vanadium-carbon-iron products. Vanadium also was important in vanadium-aluminum master alloys prepared for additions in producing titanium-based alloys. About 270 firms throughout the United States reported consumption of intermediate products in 1978. Major end use distribution: transportation, 30%; machinery, 26%; construction, 18%; and chemicals, 6%.

b. U.S. Statistics:

	1978
Production	10,500
Imports for consumption	7,100
Exports	3,200
Government sales	0
Apparent consumption	14,426
Industry stocks	8,700
Government stockpile	1,080
Net imports as a percentage of apparent consumption	27%
Import sources 1974-1977:	
South Afirca	56%
Chile	25%
U.S.S.R.	9%
Others	10%

c. World Production 1978:

	Mine Production	Reserves
United States	10,500	230,000
South Africa	24,800	4,000,000
Chile	1,900	300,000
Australia	0	400,000
Other Market Economies	6,950	700,000
U.S.S.R.	20,000	16,000,000

d. Alternative Sources:

Domestic resources are more than adequate to supply current national needs, but a substantial part of the U.S. demand is being met by foreign sources because of price advantages. However, a lead time of 2 to 3 years is needed to develop the additional domestic resources needed in a national emergency.

Steels containing various combinations of other alloying ingredients can be substituted for steels containing vanadium. Among the various metals that are interchangeable to some degree with vanadium are columbium, bolybdenum, manganese, titanium, and tungsten. Platinum may be used as a substitute for vanadium compounds as a catalyst in some chemical processes. The costs of these materials influence their usage.

Thus, the sea lanes to South Africa would be essential for imports of vanadium during the first year or two of a national emergency.

46. ZINC (Data in thousand metric tons of metal)

a. Domestic Production and Use:

The U.S. is a major consumer of zinc. Zinc is a versatile and widely used nonferrous metal that is essential to modern civilizations. The value of mine production in 1978, based on the price of prime Western metal, was $212 million. The 25 leading mines accounted for 97% of the domestic recoverable mine production, with the leading five producing 41%. Major producing states were Tennessee, 29%; Missouri, 19%; Idaho, 10%; and New Jersey, 9%. Pennsylvania, Texas, Idaho, Oklahoma, and Illinois accounted for all of the smelter production of primary slab zinc. Three primary and ten secondary smelters produced slab zinc from scrap. About one-half of the consumption by approximately 600 firms was in Illinois, Michigan, Ohio, and Pennsylvania. Construction materials accounted for 41% of consumption; transportation equipment, 27%; electrical equipment, 10%; machinery and chemicals, 8%; and other, 14%. Of the zinc metal and concentrate consumed directly, galvanizing accounted for 37% of the total; zinc-base alloy, 28%; brass and bronze, 12%; zinc oxide, 12%; and other, 11%. Major coproducts and byproducts of zinc were lead, cadmium, silver, and copper.

b. U.S. Statistics:

	1978
Production:	
Mine	310
Primary slab zinc	400
Secondary slab zinc	36
Imports for consumption	
Ore and concentrates	130
Metal	560
Exports	1
Government stockpile sales	0
Apparent consumption	1,140
Industry stocks	136
Government stockpile	338
Net imports as a percentage of apparent consumption	62%

Import sources 1974-1977:

	Ore & Concentrates	Metal
Canada	56%	47%
Mexico	12%	6%
Honduras	10%	
Australia		6%
Benelux		6%
Others	22%	35%

c. World Production 1978

	Mine Production	Reserves
United States	310	22,000
Canada	1,280	28,000
Peru	570	7,000
Australia	460	19,000
Mexico	270	3,000
Other Market Economies	1,810	54,000
Central Economies	1,450	17,000

d. Alternative Sources

In an emergency, substitutes for zinc such as aluminum, plastics and paints could be used in some cases. Reserves are sufficient to permit increased production for a limited period. The limiting factor is inadequate domestic smelter capacity. However, the two major U.S. suppliers, Canada and Mexico, have enough production capacity to supply U.S. import demands at current levels. No sources beyond the Western Hemisphere need to be considered in wartime.

47. ZIRCONIUM (Data in short tons)

a. Domestic Production and Use:

Coproduct zircon (zirconium silicate) is extracted from sand deposits, along with ilmenite and rutile, by three firms in Florida and Georgia. One company with a plant in Oregon produces primary zirconium sponge and coproduct hafnium sponge. This firm and one other in New York convert zirconium sponge to ingot. Most zircon was used in the Northeastern States; 42% was used in foundry sands, 30% in refractories, 12% in ceramics, 4% in abrasives, and 12% for miscellaneous uses, including the manufacture of chemicals and production of zirconium metal and alloys for nuclear applications and chemical processing equipment.

b. U.S. Statistics:

	1978
Production	not available
Imports for consumption	88,000
Exports	9,500
Reported consumption	160,000
Industry stocks	30,000
Net imports as a percentage of apparent consumption	50%
Import sources 1974-1977:	
Australia	98%
Malaysia and India	2%

c. World Production 1978:

	Mine Production	Reserves
United States	not available	8,000,000
Australia	375,000	13,000,000
South Africa	40,000	4,000,000
Other Market Economies	16,000	8,000,000
Central Economies	large	6,000,000

d. Alternative Sources:

Chromite and some aluminum silicate minerals may substitute for zircon in certain foundry applications.

The availability of zirconium is directly related to the supply of rutile for which the U.S. depends on Australia.

CONCLUSIONS

In 1978, the U.S. imported 47 major nonfuel minerals to satisfy more than 10% of the apparent consumption of each. The foregoing examination of potential alternate sources, industry and Government stockpiles and production capacities in the Western Hemisphere indicates that the U.S. dependence on sources beyond the Western Hemisphere can be reduced to 12 mineral commodities, if necessary during wartime. Four of the twelve can be shipped by air, but the remaining eight must transit the sea lanes from two of the most mineral-rich areas of the world, Australia and South Africa.

To maintain U.S. nonfuel mineral imports at least at peacetime levels, the estimated annual flow of shipping along these lanes is 198 round trips between the U.S. and Australia and 133 round trips between the U.S. and South Africa.

Thus, these sea lanes must be protected in wartime, but the degree of protection needed for this shipping depends, of course, on the magnitude and character of the threat.

SEA	% IMPORTED	KILOTONS/YEAR	SHIPS/YEAR*	SOURCE
MANGANESE	98	1275	128	Australia
COBALT	97	9	1	Australia/S. Africa
CHROMIUM	92	1300	130	S. Africa
RUTILE	90	250	25	Australia
ASBESTOS	84	16	2	S. Africa
CADMIUM	66	3	1	Australia
ILMENITE	39	430	43	Australia
VANADIUM	27	4	1	S. Africa

*Based on 10,000 ton capacity ship.

AIR	% IMPORTED	AMOUNT	SOURCE
DIAMOND (INDUSTRIAL)	100	5 Tons	S. Africa
PLATINUM GROUP METALS	91	93 Tons	S. Africa
GALLIUM	26	3 Tons	Europe
GERMANIUM	12	3 Tons	Africa

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Mineral Commodity Profiles

Bureau of Mines, U.S. Department of the Interior
(individual titles and dates below)

MCP	Title	Date
1	Chromium	1977
2	Phosphate	1979
3	Copper	1977
4	Nickel	1977
5	Cobalt	1977
6	Asbestos	1977
7	Manganese	1977
8	Vanadium	1977
9	Lead	1977
10	Columbium	1978
11	Potash	1978
12	Zinc	1978
13	Iron Ore	1978
14	Aluminum	1978
15	Iron and Steel	1978
16	Tin	1978
17	Stone	1978
18	Titanium	1978
19	Vermiculite	1978
20	Fluorine	1978
21	Tungsten	1978
22	Platinum	1978
23	Sand and Gravel	1978
24	Silver	1978
25	Gold	1978
26	Cement	1978